After DALI: A Look at What's Next

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IF YOU'RE INVOLVED IN COMMERCIAL LIGHTING DESIGN THESE DAYS, YOU HAVE probably heard about DALI. Although few DALI ballasts are sold today (compared to "analog" dimming ballasts), the numbers are increasing, and all the major ballast companies now either produce ballasts obeying the DALI protocol or will do so in the near future. DALI (Digital Addressable Lighting Interface) can be viewed less as an end in itself, but rather as a stepping-stone to a more complete and more capable building equipment automation system. I envision a time when all building systems-lighting, HVAC, envelope systems, even security and life safety-are effectively integrated, from the smallest device and sensor all the way to the Internet. Such a vision implies an integrated infrastructure of intelligent systems and components that are able to communicate wirelessly with one another in order to maximize comfort and reduce energy consumption. In the smart building of the future, the building operator and occupants will have appropriate access to all building comfort systems, not just lighting, and they will effortlessly exert this control to accomplish useful things in buildings. The capabilities and requirements of such smart building systems greatly exceed the capabilities of DALI, which was designed to control lighting ballasts only.

WHAT IS DALI?

While many A|L readers are already familiar with DALI, it is worth quickly reviewing the basic concept behind this technology. DALI is a digital communications system that sends digital signals over a cable to provide full dimming and switching control of fluorescent lights down to the individual ballast level. Each DALI ballast has an address and can be individually controlled from digital signals transmitted over a pair of control wires. The attraction of DALI is that all DALI ballasts in a zone are connected in parallel to the two control wires (technically, a "field bus" or "data bus"). Even though all the ballasts share the one data bus, they can be addressed either individually or in groups, as shown in Figure 1. This simplifies wiring and installation. The DALI field bus is particularly convenient for lighting applications because the wire polarity does not matter, and the power supply runs sufficient current through the field bus to power the DALI chips that reside in each ballast
But DALI has significant limitations. First, it is a wired system. To use DALI in a building, one has to install additional wiring in the ceiling. Adding wiring to existing buildings is an expensive proposition and all wired systems are highly susceptible to wiring errors. This generally limits DALI to new construction or major renovations where the additional wiring can be integrated into the electrical design from the beginning. The huge existing inventory of commercial building floor space-some 60 billion square feet-is economically unattractive

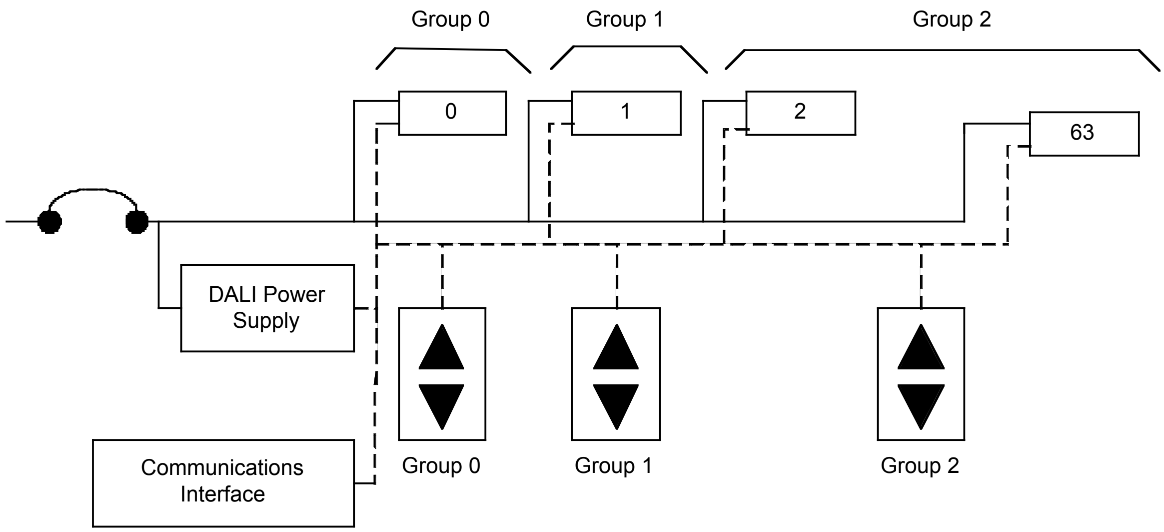

Fig. 1: Illustration showing several DALI ballasts, switches, and other components connected to a digital field bus (dashed lines)

for DALI (Buildings Core Data Book, Department of Energy, Office of Building Technologies, 2002). To comprehend the second limitation, it should be understood that any complete control system consists of three types of devices: actuators, sensors, and controllers. (See Figure 2.)

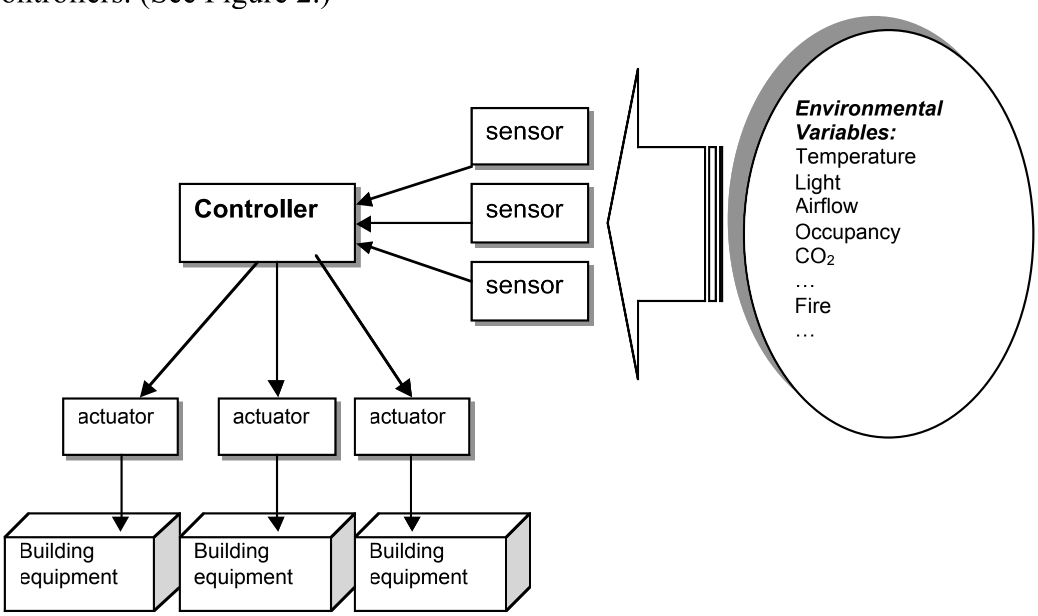

Fig. 2: Diagram showing relationship between controller, actuators, and sensors in a typical building control application. Sensors detect the key environmental parameters, while the controller "decides" which actuator is to be controlled and how. The actuators operate the building equipment, which, in turn affects the building environment.

Actuators are devices that activate something (like a ballast, switch, or motor); sensors measure environmental parameters (such as light or occupancy); the controller decides which actuators to control based on the sensor inputs. DALI was only designed to operate lighting ballasts, which are a specialized type of actuator, it does not address sensors at all, so a large class of control devices is not handled by the DALI protocol. Recently, the NEMA Joint Sections Committee on DALI has taken up the challenge to extend the DALI protocol to a limited range of sensors. But this should only be considered a band-aid on the lighting control problem rather than a complete solution.

A WIRELESS FUTURE

Given the limitations on DALI, are there any other full-featured communications protocols that would be up to the challenge? The answer is increasingly "yes," but there are also uncertainties to the path ahead. Most experts agree that the only way lighting controls could significantly penetrate the existing building market is to adopt a wireless (radio frequency or RF) communications protocol that eliminates the need to install control wiring in the ceiling. In the last year, there are three main wireless protocols to emerge from the electronics and computer industry that may be appropriate for building control. The key technical attributes of these RF protocols are given in Table 1. Of these protocols, ZigBee (a name that alludes to the zigzagging of bees) is probably the most appropriate for building (and lighting) control, because it supports 64,000 nodes per master, has short latencies i.e., fast response time), and consumes relatively little power. Since here are many lighting points within a typical building, being able to control thousands of nodes per master is a definite advantage.

	WiFi ***IEEE 802.11b***	**Bluetooth** ***IEEE 802.15.1***	***Zigbee*** ***IEEE 802.15.4***
System Resource	1 MB	250 kbytes	4 - 32 kbytes
Battery Life (days)	Hours	Days	Months
Latency	Up to 3 sec	Up to 10 sec	30 msec
Nodes per network	30	7	64,000
Bandwidth	11 Mbits	1 Mbit	64-128 kbytes
Range (meters)	Up to 100	Up to 10	Up to 75

Fast response times are also a must for lighting control: when a user throws a switch, they expect virtually instantaneous response. ZigBee's 30-millisecond response time is far faster than the other two protocols, and thus more appropriate for rapid control of lighting circuits. Finally, ZigBee nodes consume little power and are optimized to "wake up" quickly. To save lower. most wireless systems "sleep:' and only "wake up" when scheduled or commanded to do so from another node or controller compared to the other protocols, ZigBee has low-data rates: in other words, it speaks slowly. But this is not of great concern for lighting equipment

After all, a lighting fixture doesn't have very much to say! For these reasons, ZigBee is increasingly being considered internationally for building and lighting control systems.

Note that ZigBee is not the only way to accomplish wireless communications in buildings. A number of companies, including Dust Networks, Crossbow, and Millenial offer products of different degrees of suitability and scope. It may turn out that no one protocol is used for all building control applications Rather a number of protocols may be used, each possibly optimized for the subsystem it controls. For example, a proprietary mesh networking protocol may be adapted at the switch leg (usually room) basis, while a wired system is used to control the local lights.

Although ZigBee, as well as other mesh networks, offer great promise for wireless building control. there is still a need for a "higher-order" framework under which to operate this confederacy of building control networks. This framework is usually embodied as an intelligent gateway- an electronic routing device that communicates with standard Ethernet on one side and the different relevant building communications protocols on the other. A number of companies, such as EnvEnergy and Aftek, now produce such gateways, and some can be optimized for multiple building control protocols. A multi-protocol intelligent gateway is the key to implementing robust wireless networking for smart building control. Programs running on the gateway will take care of the messy business of commissioning, diagnosing, and operating the disparate attached control devices connected to the gateway. Most of these programs will work across different networks allowing the software industry to leverage its programming efforts. To be successful. however, there is a need for a Standard that will formalize the operation of different aspects of the smart building network to reduce the risk to manufacturers that will produce the basic control devices and networks. The Institute of Electrical and Electronics Engineers (IEEE) is an enormous organization (almost 400,000 members worldwide) and has the expertise and reputation to devise such a standard. There are two reasons for adopting a standard at the gateway level: First. the building controls and sensor industry need a networking solution that works regardless of which wired and wireless protocols win the building controls horse race. We simply cannot know at this point how market forces will determine which protocol(s) will be adapted for each building subsystem. Some buildings will have both wired and wireless control devices that need to be able to “talk”. Secondly, the smart building of the future will necessarily operate a wide variety of sensors and actuators, each with its own unique properties and capabilities. The IEEE 1451 Standard on Sensors and Actuators (implemented in 1997) is a suite of guidelines each aimed at standardizing a different aspect of communications for smart transducers (sensors and actuators). Section five of IEEE 1451. for example, is concerned with wireless communications and in particular how ZigBee (and other major protocols) function. While 1451.5 is not part of the ZigBee specification, ZigBee is part of the 1451.5 standard. IEEE 1451.5 and ZigBee are complimentary standards. Whereas ZigBee is concerned with the communications protocol, IEEE 1451 is concerned with how data elements within devices are modeled and documented. In the smart building of the future, different networks and devices will be seamlessly operated from intelligent gateways using the IEEE 1451 Standard.

In the smart building of the future, the building operator and occupants will have appropriate access to all building comfort systems, not just lighting, and they will effortlessly exert this control to accomplish useful things in buildings.

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